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HIGH-GAIN, LONG-PERIOD SEISMOGRAPH STATION INSTALLATION REPORT

CHIANG MAI, THAILAND

by

Andrew J. Murphy

Lamont Doherty Geological Observatory

of

Columbia University

31 March 1971

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13. ABSTRACT

This report describes the installation of a high-gain, long-period seismograph system at Chiang Mai, Thailand. The station is located at 18°47'24" north latitude, 98°58'37" east longitude, at an elevation of 416 m above sea level in a concrete surface vault adjacent to the World-Wide Standardized Seismic Network (WWSSN) station CHG instrument vault. The system consists of three Geotech seismometers with natural periods of 30 sec (one vertical and two horizontal) each with two velocity transducers and one displacement transducer. One velocity transducer is coupled to a Kinemetrics galvanometer with a natural period of 100 sec from which the signal is amplified by a photo-tube amplifier (P.T.A.) and recorded photographically and digitally (designated high-gain component). The signal from the second velocity transducer is coupled directly to a recording galvanometer and recorded photographically (designated standard component). The displacement transducer signal is recorded digitally. The system can operate with gains up to 500,000 at periods of 35 to 45 sec. This high sensitivity has been achieved by isolating the seismometer from barometric changes, by electronically filtering out the 6 second microseisms and by shaping the instrument response to correlate with a natural low in the earth-noise spectrum. The seismometers and phototube amplifiers are housed in a chamber sealed from the environment by three ship-type bulkhead doors. The photographic drum recorders, recording galvanometers, control console and digital data acquisition system are located in the WWSSN building about 10 m from the seismometers.

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LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

COLUMBIA UNIVERSITY

PALISADES, NEW YORK, 10964

HIGH-GAIN, LONG-PERIOD SEISMOGRAPH STATION

STATION:	Chiang Mai, Thailand
	WWSSN Abbreviation -- CHG
STATION DIRECTOR:	Dr. Charoen Charoen-Rajapark
	Director General
	Meteorological Department
	Office of Prime Minister
	Bangkapi, Bangkok
	Thailand
	Cable: Meteor Bangkok
STATION ENGINEER:	Lt. LA-Iad Sungchaya
	Meteorological Department
	Bangkapi, Bangkok
	Thailand
STATION OPERATOR:	Mr. Aurachoon Jayavanana
	c/o Meteorological Office
	Chiang Mai Airport
	Chiang Mai, Thailand

STATION INSTALLATION: Dates: 7 November 1970 to

10 December 1970

Personnel: George P. Hade, Jr. (L. D. G. O.)

Andrew J. Murphy (L. D. G. O.)

La-Iad Sungchays (Meteor. Depart.)

Aurachoon Jayavanana (Meteor.

Depart.)

I: STATION DESCRIPTION

STATION LOCATION

Coordinates:	Latitude	18°47'24" N		
	Longitude	98°58'37" E		
Elevation above sea level:				
	High-Gain Seismometers:		Z	416 m
			N-S	416 m
			E-W	416 m
	Existing WWSSN vault:		416.43 m	

The city of Chiang Mai is located in northern Thailand about 600 km north-northeast of Bangkok, 400 km northeast of Rangoon, and approximately 300 km inland from the Andaman Sea (Figure I-1). The station property is located 6.4 km west of the riverfront center of Chiang Mai in a shallow hard-rock quarry. The quarry was closed in 1962 when the Thai Meteorological Department obtained the property for use as the site of a World-Wide Standard Seismograph Network station. The WWSSN instruments have been in continuous operation since March 2, 1963.

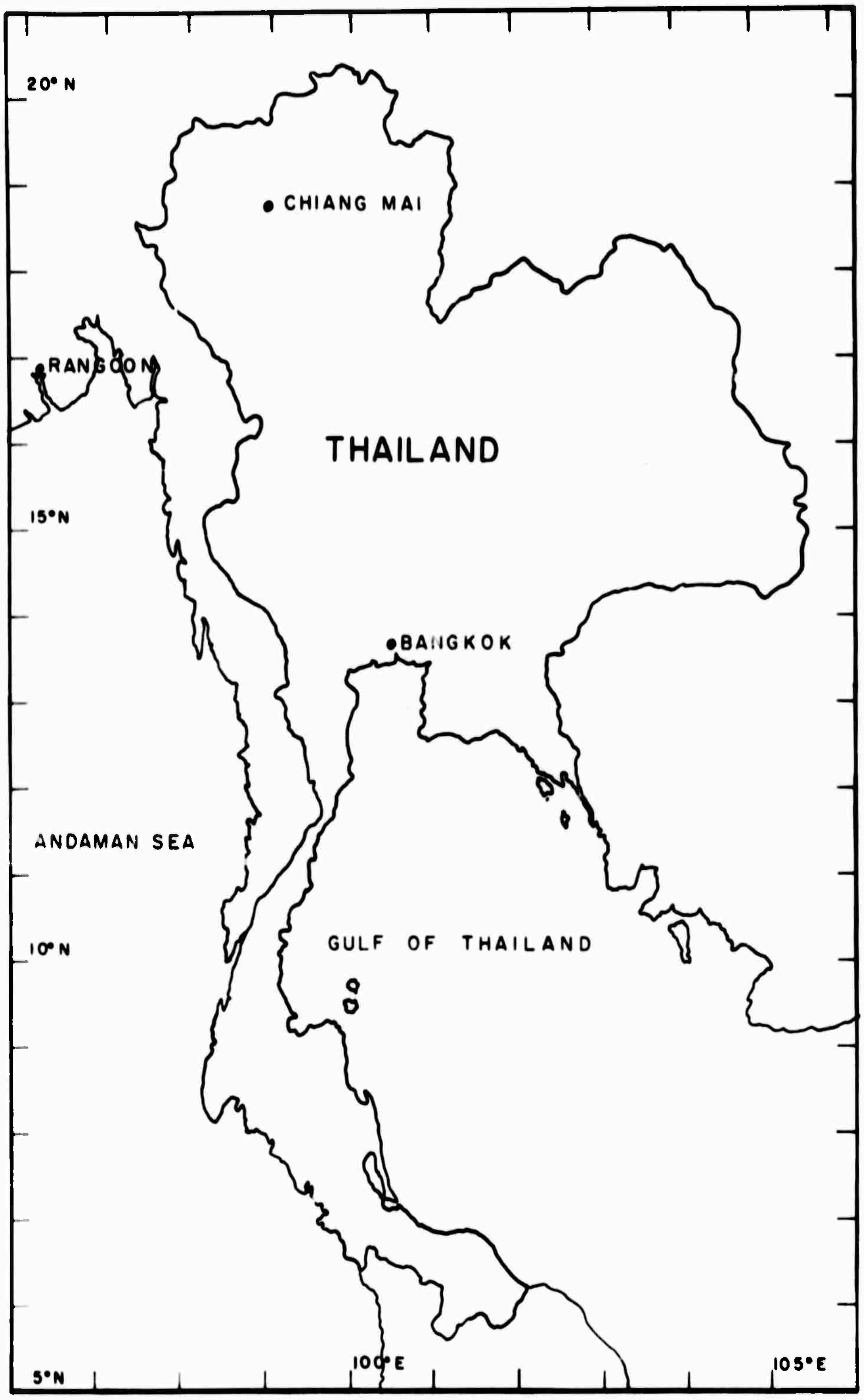


Figure I-1: Map of Thailand showing location of Chiang Mai.

LOCAL PHYSIOGRAPHY

Chiang Mai is located in the Mai Nam Ping River valley, the floor of which is at an elevation of about 350 meters above sea level. The Mai Nam Ping River valley is part of the Phi Pan Nam physiographic subprovince. This subprovince is characterized by a series of parallel, mountainous ridges that strike north-northeast. It is similar to the Valley and Ridge Province of the eastern United States where the rivers have eroded the folded rocks, cutting valleys in the softer beds and leaving the harder beds as ridges. The Chiang Mai basin is typical of the river basins of the subprovince with sluggish stream meandering across the narrow flood plain. The winding course of the stream of the interbasin gorges indicate that the drainage systems have been superimposed on former peneplained surfaces.

The station property is located near the foot of one of the mountainous ridges at the 416 meter level (Figure I-2). All but a half dozen trees have been cleared from the property while the remainder of the ridge is covered with 10 to 11.5 meter (30 to 40 foot) trees and a great deal of shrub-type vegetation.

CLIMATE

The climate is savanna with an average rainfall (averaged from

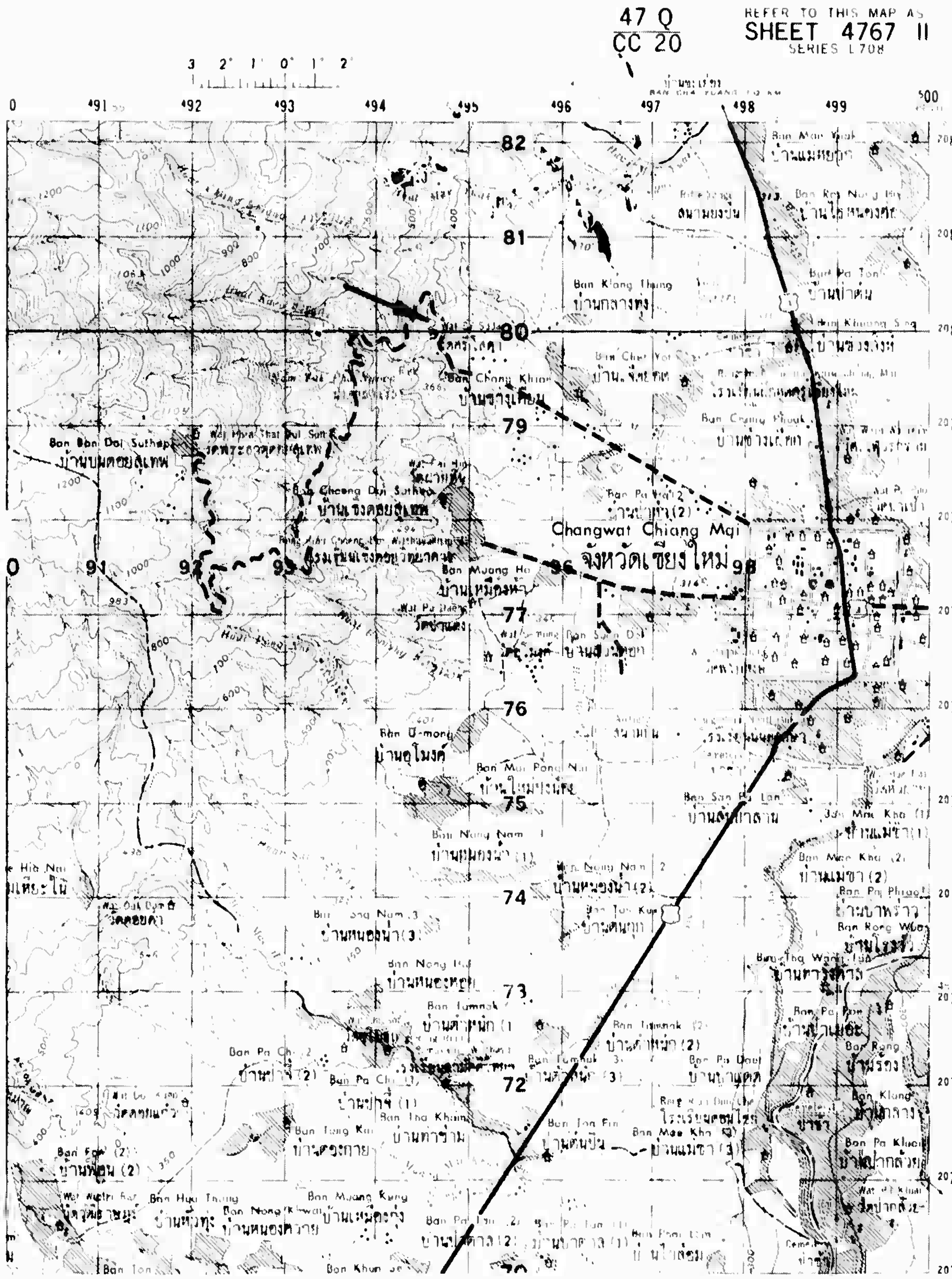


Figure I-2: Topographic map of Chiang Mai area. Seismographic station is indicated by arrow.

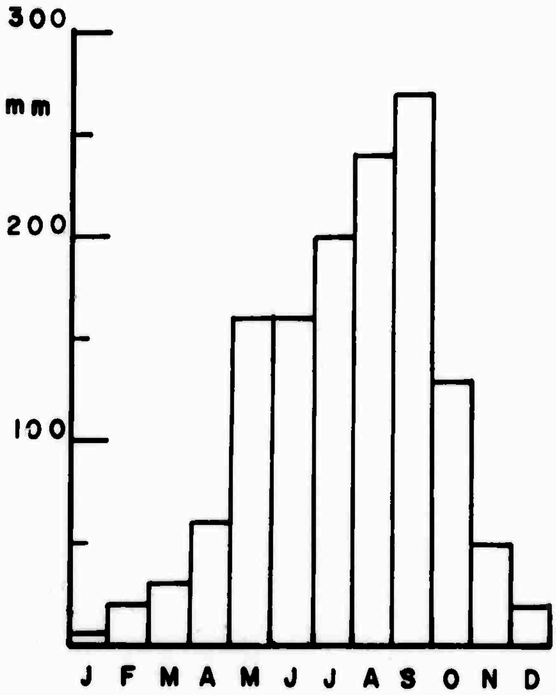


Figure I-3a: Histogram of the monthly rainfall at the Chiang Mai Airport averaged over the period of 1931-1960.

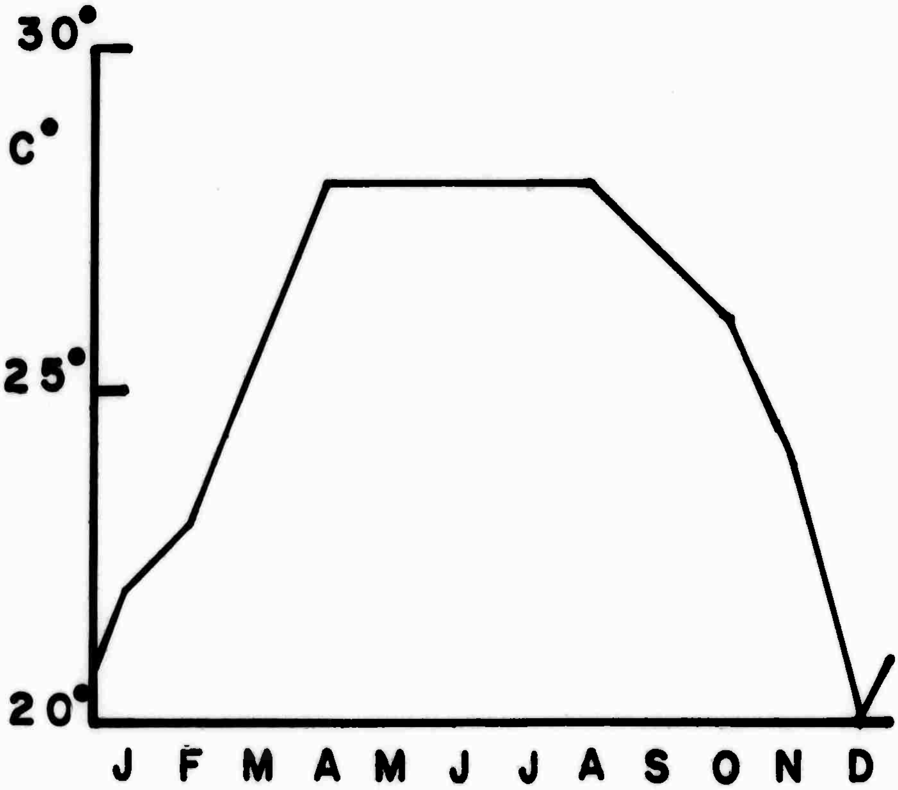


Figure I-3b: Graph of the monthly mean temperature at the Chiang Mai Airport averaged over the period of 1931-1960.

1931 to 1960) of 1253 mm/yr (51 inches/yr.). The rainy season occurs from May to September (Figure I-3a). The annual average temperature is 26° to 28° C (79° to 82° F (Figure I-3b). The prevailing winds are out of the southwest or south-southwest at 20 to 30 km/hr (12 to 20 mph). The rock quarry, in which the station is located, faces east and consequently receives many hours of direct sunlight daily.

LOCAL GEOLOGY

Little is known about the geology of the area around Chiang Mai. The surficial geologic map of Thailand (Brown, 1953) indicates that the station is on alluvium or terrace deposits (Figure I-4). The bedrock, however, occurs at less than a meter below the surface, and appears to be the Triassic granites that the map indicates outcrop just to the east of Chiang Mai. The station is located in a shallow quarry; the quarry rock is devoid of large fractures and shows no signs of scaling or deep weathering.

STATION'S RELATION TO MAN-MADE STRUCTURES

The new long-period seismometer vault is located inside a fenced compound approximately 100 meters from an improved mountain road. Within the compound (the light area noted in Figure

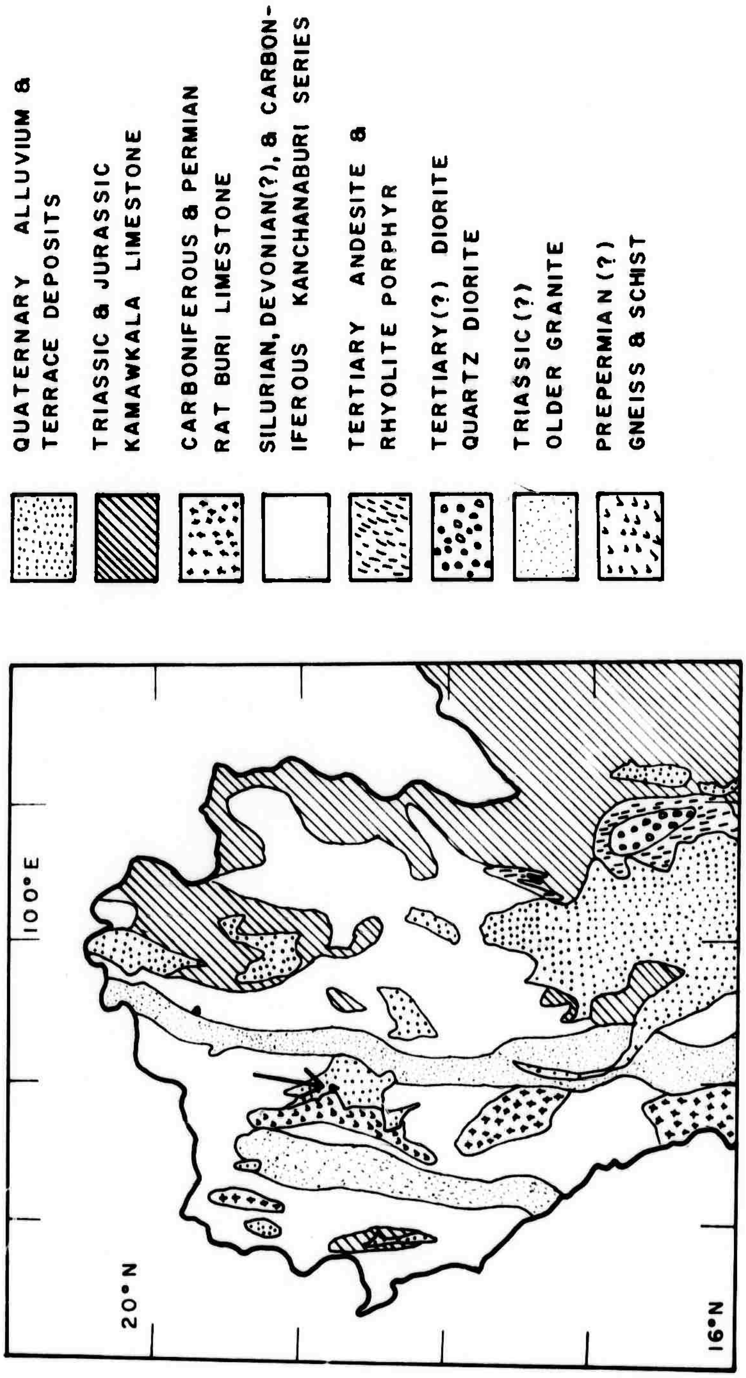


Figure I-4: Geologic map of Northwest Thailand. Chiang Mai is indicated by arrow. (Brown, 1953).

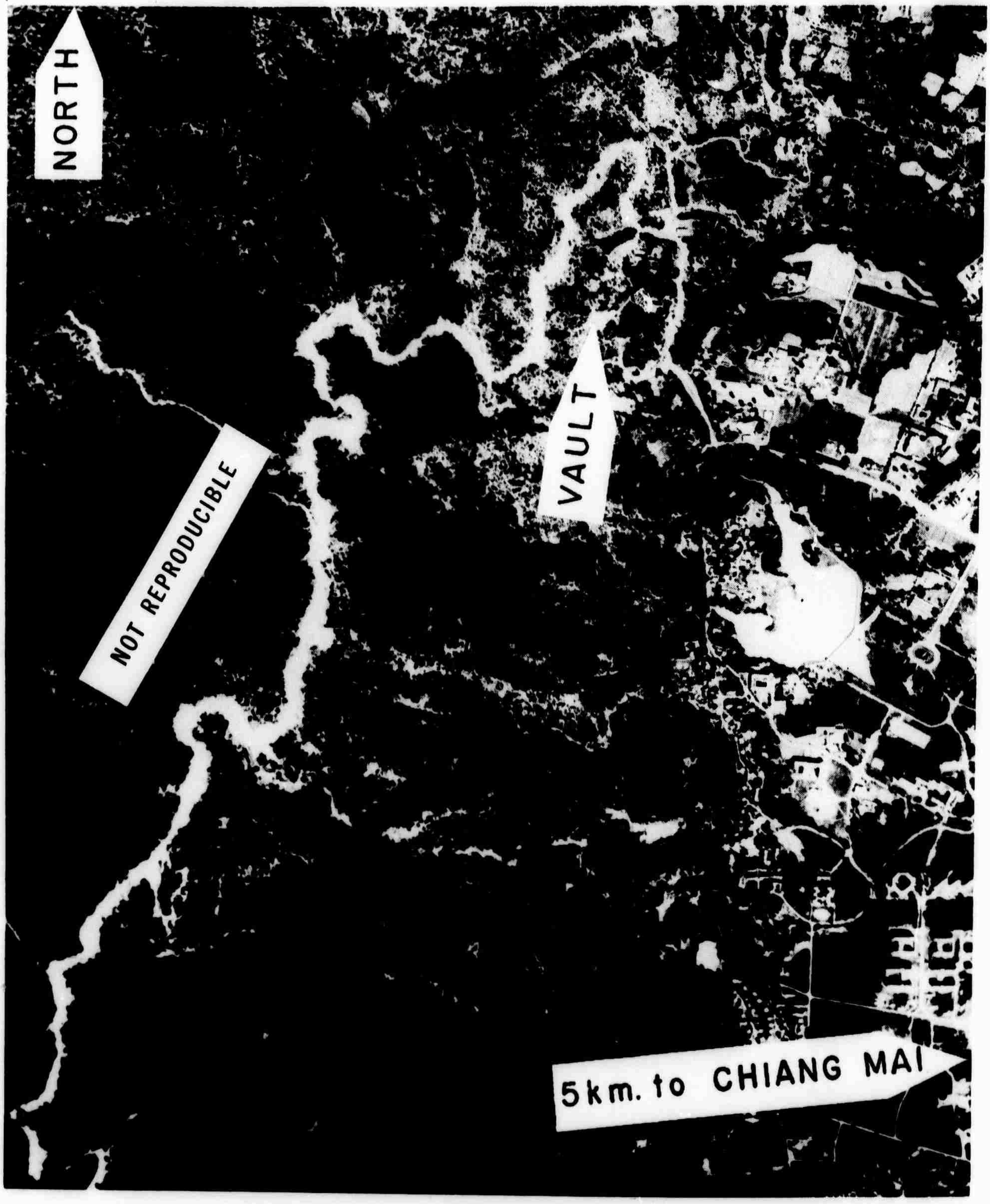


Figure I-5: Aerial photograph of the immediate vicinity of the seismographic station. The area of the photograph is 2.25 km x 1.88 km.

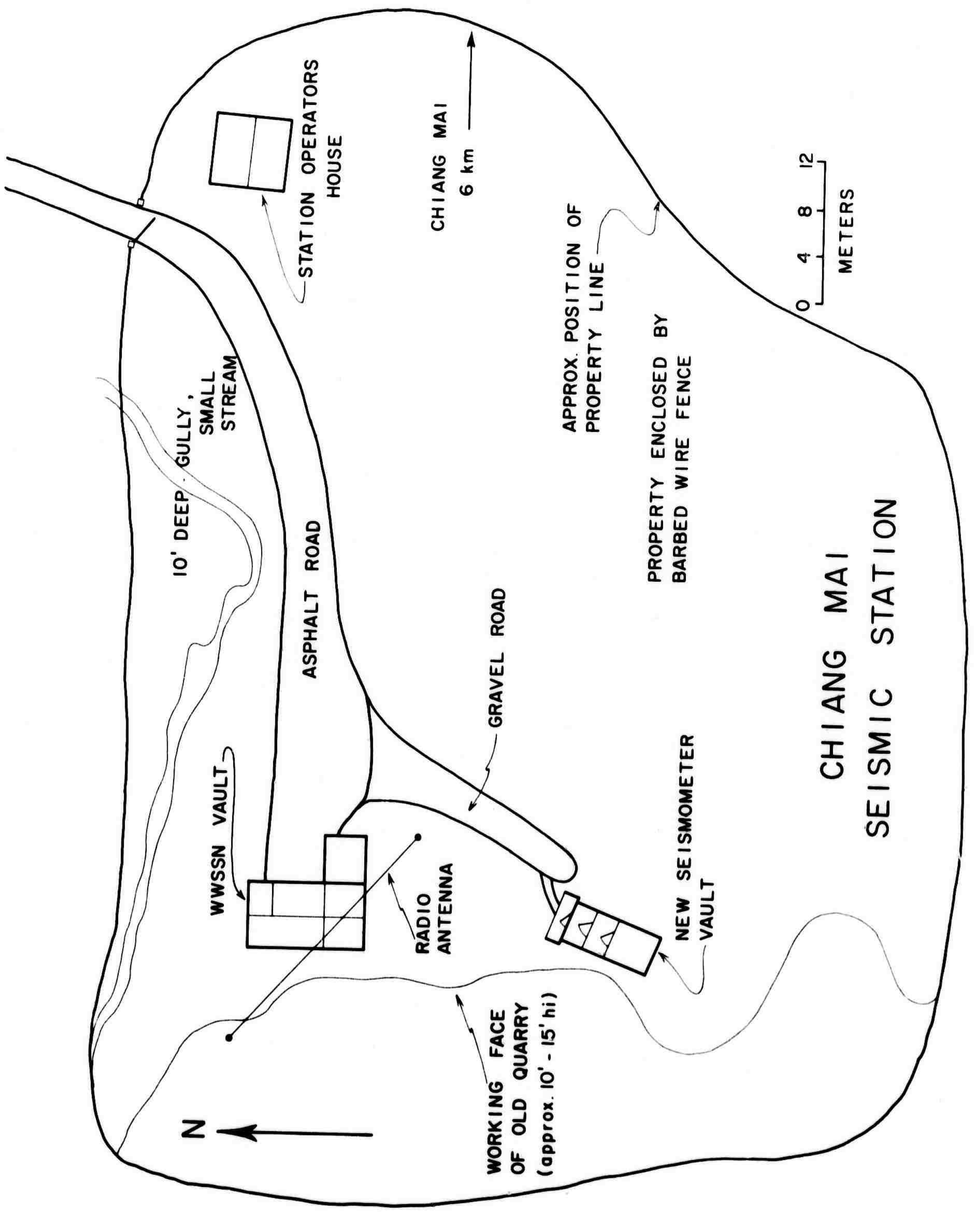


Figure I-6: Sketch of Chiang Mai Seismic Station.

I-5) there are two other buildings. One of these is a poured concrete building that serves as the WWSSN vault and houses the recording and control equipment for both the WWSSN system and the High-Gain system. The other building, the station operator's home, is a two-story wooden structure approximately 8 meters square and about 60 meters from the new vault (Figure I-6).

At the time of installation, the mountain road was being improved. The construction involved daily blasting within 2 or 3 km of the vault and 50 to 75 ten-ton loads of soil passing approximately 100 meters from the vault. This construction should be finished within six months. Presently, only a few heavy vehicles (15 ton gross) are anticipated to use the road daily.

There are no other man-made structures in the area that might be expected to be sources of long period noise.

II: STATION CONSTRUCTION AND INSTALLATION

The station equipment is housed in two buildings. The seismometer vault and phototube amplifier (P. T. A.) room are located in a new concrete building (the new vault). The recording and the control equipment are housed in the pre-existing WWSSN vault and recording building, which is 10 m north of the new vault.

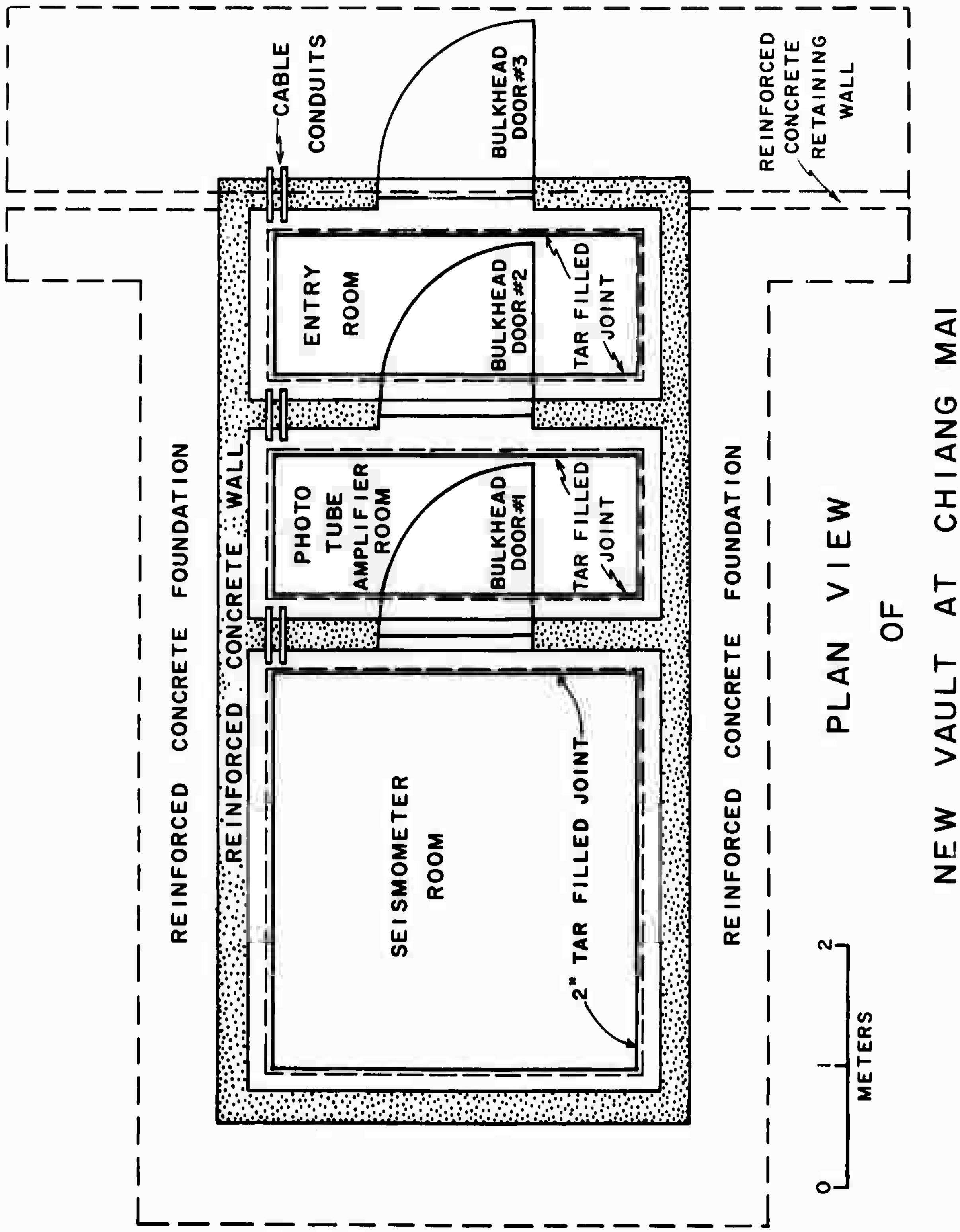


Figure II-1: Plan of new seismic vault at Chiang Mai.

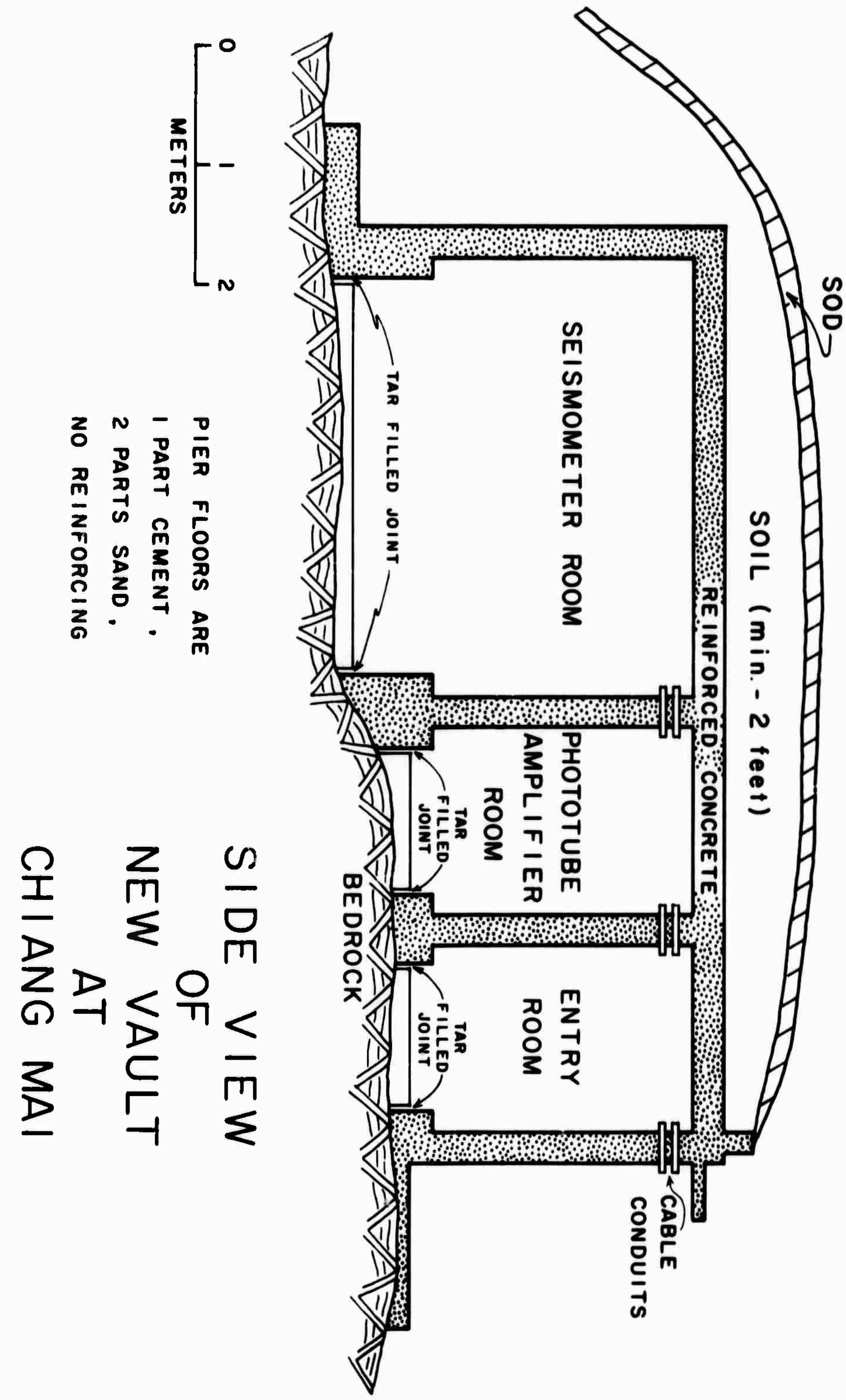


Figure II-2: Cross-sectional view of new seismic vault at Chiang Mai.

CONSTRUCTION OF THE NEW VAULT

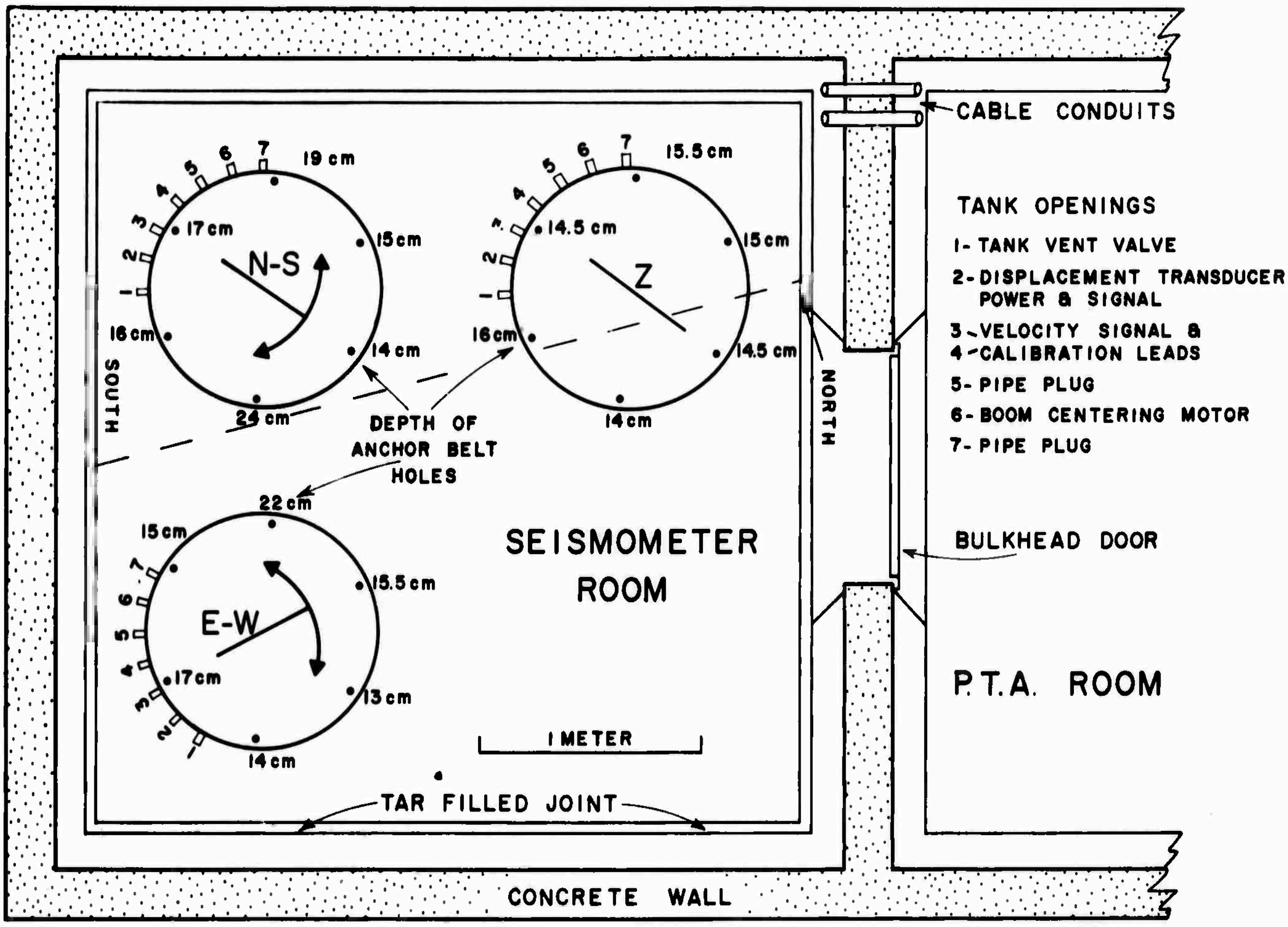
The new seismometer vault at Chiang Mai was designed by Dr. Wiroj Sangvaree of the Thai Meteorological Department to meet some general specifications given by Lamont-Doherty Geological Observatory (Figure II-1 and 2). All aspects of the construction from washing the bedrock beneath the pier areas (Plate 1), placing the reinforcing steel in the walls and ceiling, forming the piers, walls and roof (Plate 2), handmixing and pouring the concrete (Plate 3) to backfilling and sodding the vault (Plate 4) were carefully supervised by La-Iad Sungchaya (Plate 5), also of the Meteorological Department. The finished product is a well built surface vault that is reasonably airtight and thermally shielded. The time constant of the vault response to a sudden pressure variation is about 1 hour. Some of the factors contributing to this low time constant are the careful preparation of the rock surface, the wide footings with large surface area contact with the bedrock (Figure II-2) and to the application of epoxy paint to all interior surfaces except the floor. The entire vault is covered with a plastic sheet buried 15 cm (6 inches) below the sod to prevent excessive amounts of moisture from penetrating to the vault.

SEISMOMETER - P. T. A. CHAMBER

The seismometer vault and P. T. A. chamber are located in the new vault, which is a steel-reinforced concrete building 7.5 m by 3.75 m (25 feet by 12 feet). As shown in Figure II-1 the building consists of three rooms, the seismometer vault, P. T. A. room, and an entry room. Each of these rooms is sealed by a ship-type bulkhead door. To thermally shield the seismometer vault, at least .75 meter (2 feet) of soil was placed over the entire building except the entrance wall (Figure II-2).

The bedrock surfaces beneath the entire new vault were meticulously prepared using hammer and chisel to remove all loose rock. Extreme care was exercised in cleaning the surface area of pebbles and sand grains with wire brushes and pressurized water. A mixture of one part cement and two parts sand was carefully poured and hand-worked to insure a firm bond to the bedrock and to obtain a dense seismometer pier. No reinforcing devices were placed in the pier floors of any one of the three rooms so that the P. T. A. and Entry rooms are available for additional instrumentation at a later date. Because of the uneven surface of the bedrock, there is a 50 cm (20 inch) step from the level of the P. T. A. floor down to the seismometer pier. A 5 cm (2 inch) wide tar-filled joint was placed between the pier-floor and the wall in all three rooms.

The seismometer pier was surveyed for a north-south line



PLAN OF SEISMOMETER ROOM
CHIANG MAI

Figure II-3: Plan of Seismometer Room showing:
(a) Alignment of seismometers
(b) Position of cable conduits in pressure tanks
(c) Position of surveyed North-South pins at ends of indicated North-South line.

to $\pm$ 0.5° and permanently marked by nails driven into opposite points on the edge of the pier (Figure II-3). Figure II-3 also shows the alignment of the seismometers and the position of the cable conduits in the tanks. Two and one half cm by ten cm (one inch by four inch) teak boards were attached to the concrete walls to provide a surface on which cable clamps could be anchored.

The phototube amplifiers, their power supplies, and the power supply for the displacement transducer are housed in the P. T. A. room (Figure II-4).

RECORDING FACILITIES

The two three-drum photographic recorders required for this project have been installed one on top of the other as shown in Plate 6 because of spatial limitations in the pre-existing WWSSN recording room. Similarly, the recording galvanometers had to be stacked; the 100 sec, standard (low-gain) galvanometer on the original concrete pier and the 0.3 sec. high-gain galvanometer on the rigid, wood-topped steel benches (Plate 7). The galvanometer pier is isolated from the floor by a one inch wide tar-filled joint. Cabling is again routed along two and one half cm by ten cm (one inch by four inch) teak boards attached firmly to the walls (Plate 8). All cable feed-thrus were made light-tight with "Duxseal".

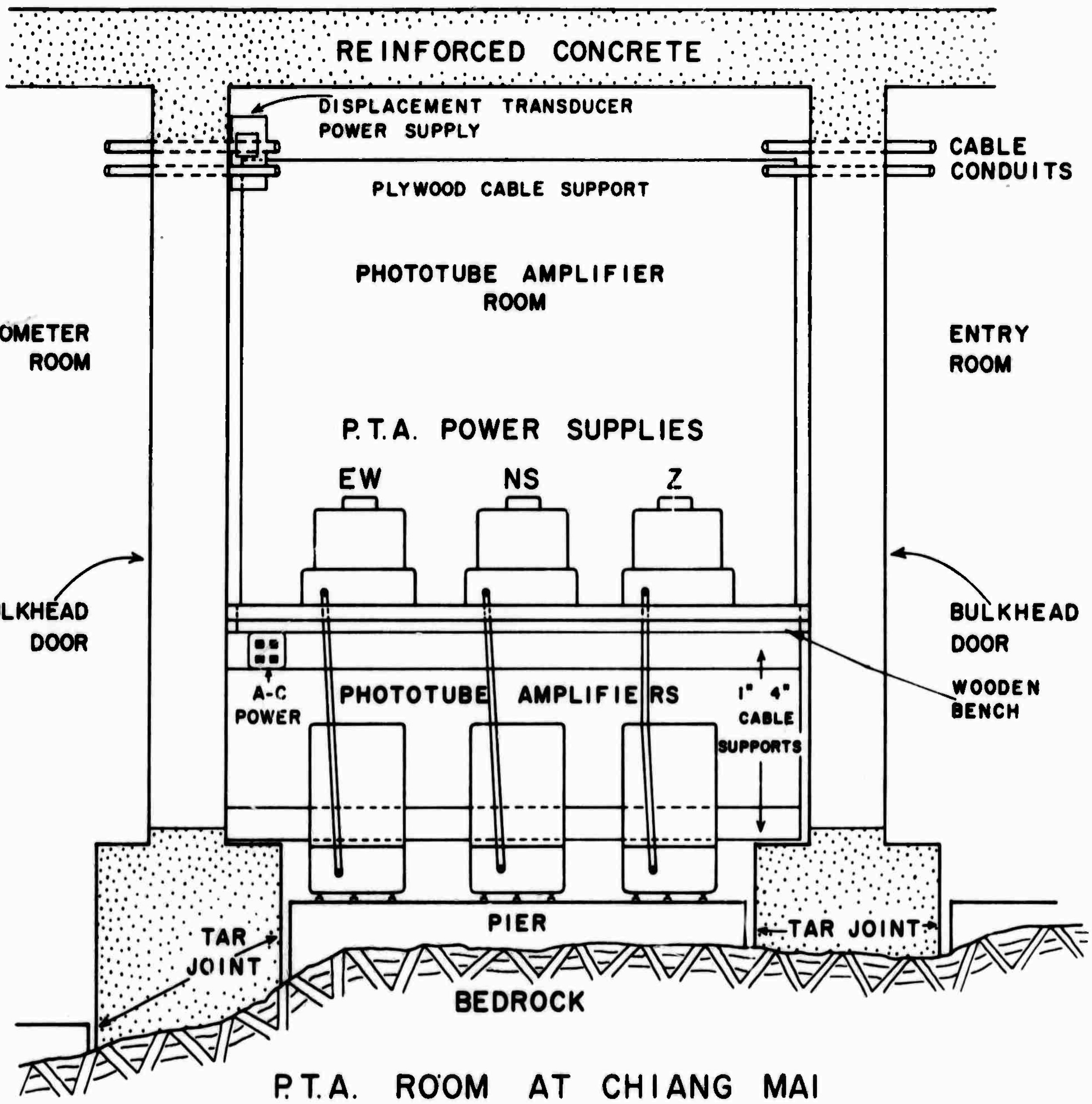


Figure II-4: Cross-sectional view of Phototube Amplifier Room.

Double light-tight doors through the developing room (Figure II-5) allow access to the recording room without interrupting the records. The power distribution panel has been mounted on the wall in the recording room.

The control console and digital acquisition system are housed in the WWSSN control room (Figure II-5).

CABLES

Details of cables used for the installation are given in Table 1. To preserve the pressure integrity of the seismometer vault and P. T. A. chamber, all the cables are potted in "Scotchcast" resin and routed through 5 cm (2 inch) galvanized pipe conduits in the concrete walls between the seismometer vault and P. T. A. room and between the P. T. A. room and entry room. The cables are routed between the two buildings in a plastic PVC-type pipe that was anchored to the quarry wall for a portion of the distance and buried for a second portion (Plate 9). In the new vault and recording room the cables are firmly fastened to the two and one half cm. by ten cem. (one inch by four inch) teak boards by means of nylon cable clamps.

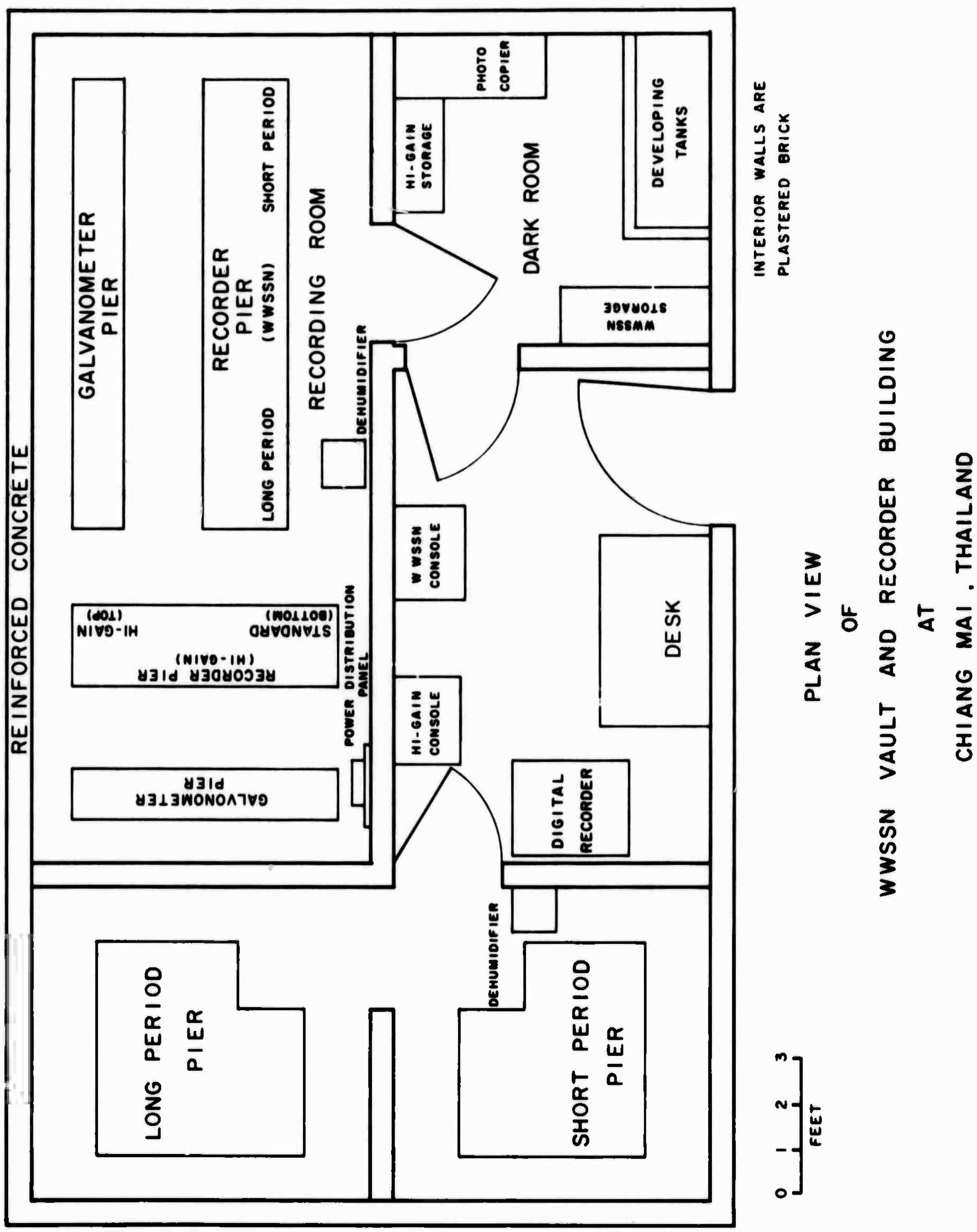


Figure II-5: Plan of existing WWSSN Vault and Recording Building.

TABLE I

CABLE DETAILS

CABLE #	DESCRIPTION		CABLE TYPE
1	E-W Velocity Low Gain Signal	Seismo to Photorec	2CS
2	E-W Velocity High Gain Signal	Seismo to P. T. A.	2CS
3	E-W Primary Calibration	Seismo to Console	2CS
4	E-W Secondary Calibration	Seismo to Console	2CS
5	N-S Velocity Low Gain Signal	Seismo to Photorec	2CS
6	N-S Velocity High Gain Signal	Seismo to P. T. A.	2CS
7	N-S Primary Calibration	Seismo to Console	2CS
8	N-S Secondary Calibration	Seismo to Console	2CS
9	Z Velocity Low Gain Signal	Seismo to Photorec	2CS
10	Z Velocity High Gain Signal	Seismo to P. T. A.	2CS
11	Z Primary Calibration	Seismo to Console	2CS
12	Z Secondary Calibration	Seismo to Console	2CS
13	E-W Displacement Signal/ Boom Center Monitor	Seismo to Console	2CST
14	N-S Displacement Signal/ Boom Center Monitor	Seismo to Console	2CST
15	Z Displacement Signal/ Boom Center Monitor	Seismo to Console	2CST
13C	E-W Displacement Signal	Console to Digital	2CST
14C	N-S Displacement Signal	Console to Digital	2CST
15C	Z Displacement Signal	Console to Digital	2CST

TABLE I (Continued)

CABLE #	DESCRIPTION		CABLE TYPE
16	E-W Boom Centering Motor	Console to Seismo	2CST
17	N-S Boom Centering Motor	Console to Seismo	2CST
18	Z Boom Centering Motor	Console to Seismo	2CST
19	E-W Displacement Transducer Power Supply	P. T. A. to Seismo	3CST
20	N-S Displacement Transducer Power Supply	P. T. A. to Seismo	3CST
21	Z Displacement Transducer Power Supply	P. T. A. to Seismo	3CST
22	E-W Velocity High Gain Signal	P. T. A. to Digital	2CST
23	E-W Velocity High Gain Signal	P. T. A. to Photorec	2CST
24	E-W P. T. A. Gal Centering Monitor	P. T. A. to Console	2CST
25	E-W P. T. A. Gal Center Motor	Console to P. T. A.	2CST
26	N-S Velocity High Gain Signal	P. T. A. to Digital	2CST
27	N-S Velocity High Gain Signal	P. T. A. to Photorec	2CST
28	N-S P. T. A. Gal Centering Monitor	P. T. A. to Console	2CST
29	N-S P. T. A. Gal Centering Motor	Console to P. T. A.	2CST
30	Z Velocity High Gain Signal	P. T. A. to Digital	2CST
31	Z Velocity High Gain Signal	P. T. A. to Photorec	2CST
32	Z P. T. A. Gal Centering Monitor	P. T. A. to Console	2CST
33	Z P. T. A. Gal Centering Motor	Console to P. T. A.	2CST

TABLE I (Continued)

CABLE #	DESCRIPTION		CABLE TYPE
	Unlabeled Spare	Seismo to Digital	2CS
	Unlabeled Spare	Seismo to Digital	2CST

Notes: (1) Cable Type 2CS 2 Conductor Solid (#18 wire)

2CST 2 Conductor Stranded (#16 wire)

3CST 3 Conductor Stranded (#16 wire)

All cables with milar shield and separate earth conductor

(2) Cables 13C, 14C, 15C:

"C" denotes a cable connecting the displacement transducer output of the seismometer from the control console to the digital system enabling the displacement signal to be digitally recorded as well as to be the monitor for boom position.

(3) Abreviations for end positions of cable runs:

Seismo - Seismometer Room

P. T. A. - Phototube Amplifier Room

Photorec - Photographic Recording Room

Console - Control Console in Control Room

Digital - Digital Acquisition System in Control Room

(4) All 110V is #10-3 plastic covered cable.

III: STATION FACILITIES

AVAILABLE COMMERCIAL POWER

Voltage: 240 V

Frequency: 50 Hz

Reliability: The voltage level delivered to the station was found to be significantly lower than the nominal 240 V. The voltage, which varies between 180 V and 210 V and is usually at about 190 V, is greatly affected by fluctuations in the local power consumption. Although no power failures were known to have occurred during the time the installation team was in Chiang Mai (7 November to 10 December 1970), power failures normally occur at least twice a month. While equipment was not available to test the frequency, a careful examination of the length of minutes on the WWSSN records indicates that there are no apparent variations in the frequency (less than $\pm$ 5%).

The voltage level is below that given in the manufacturers specifications for the Astrodata digital system and the Geotech P. T. A. power supplies, and it may have increased the noise level, particularly on the P. T. A. output signal. This problem of voltage was corrected by a multi-position step-up transformer sent to Thailand on 2 January 1971. An uninterruptable power supply is scheduled to be installed in the Spring of 1971.

AVAILABLE TIME STANDARD

Time for the analog (photographic) records is taken from the existing WWSSN time console. The WWSSN station has a Hammerlund SD600 receiver supplied by the United States Coast and Geodetic Survey with a tuned antenna oriented northwest-southeast. Radio reception of WWVH, Honolulu (10 and 15 MHz) is very good. The Japanese station, JJY, (10 and 15 MHz) and the Fort Collins station, WWV, (10 and 15 MHz) can be received fairly well most of the time.

The digital acquisition system has a crystal oscillator time standard. Its digital clock is checked daily and corrected, if necessary, to WWVH time.

STATION TEMPERATURE AND HUMIDITY

There is no equipment in the seismometer vault to record or control pressure and temperature (e. g. , no light bulbs as heat sources). A dehumidifier is operated at all times in the recording room.

Temperature, humidity, and barometric pressure records were obtained for varying lengths of time during the installation period. The records show the known or expected meteorological conditions at this latitude (equatorial cyclic daily variation in atmospheric pressure).

Information on the effects of meteorological phenomena on this station will have to await the installation of additional meteorological instrumentation.

BACKGROUND NOISE

The microseismic activity at Chiang Mai is associated with meteorological phenomena, particularly storms in the Gulf of Siam and the South China Sea. The microseism level at this station is among the lowest encountered anywhere. The predominant microseisms have periods of 5 to 6 seconds and 16 to 20 seconds. Their amplitude is often below 0.2μ and rarely exceeds 0.5μ.

OTHER INSTRUMENTS IN OPERATION

The WWSSN standard station CHG has three short-period (To = 1 sec) Benioff variable-reluctance seismometers and three long-period (To = 15 sec) Press-Ewing seismometers. The magnifications of the components are as follows:

SP	Z	:	400,000
SP	N-S	:	400,000
SP	E-W	:	400,000
LP	Z	:	3,000
LP	N-S	:	3,000
LP	E-W	:	3,000

IV: INSTRUMENTATION

The details of the system instrumentation are given in the Lamont-Doherty Geological Observatory Technical Report entitled "High-Gain, Long-Period Seismograph Station Instrumentation". The complete system is shown in Figures IV-1 and IV-2. Amendments to the system and specific details that pertain only to the Chiang Mai installation are given below. All tests and calibrations were performed remotely from the control room. A set of magnification curves is given in Appendix II. These curves are representative of the station as of 1 March 1971 and are subject to change dependent upon variations in noise at the station. Photographs of the Chiang Mai installation are given in Appendix I.

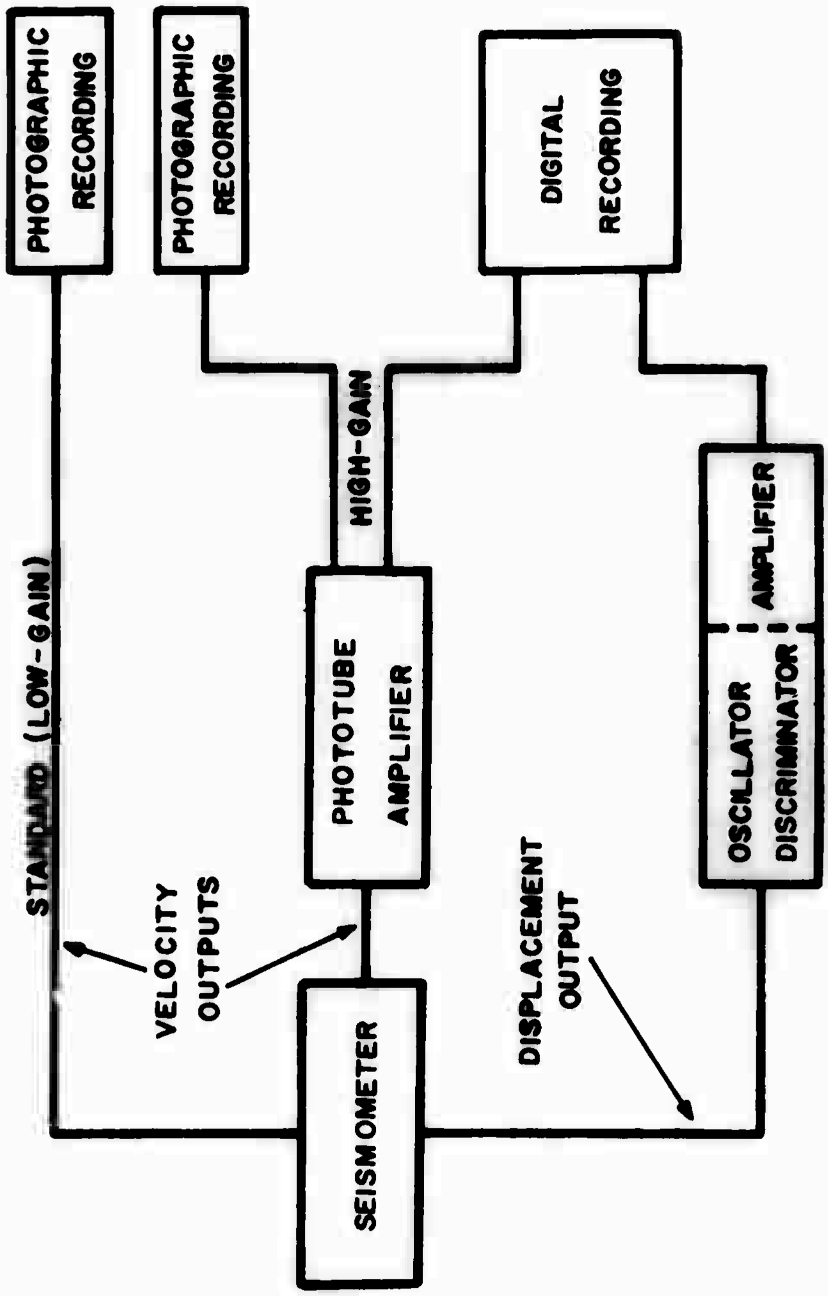


Figure IV-1: Schematic block diagram of the high-gain, long-period seismograph system.

Figure IV-2: Detailed diagram of the high-gain, long-period seismograph system. This figure is a fold out at the end of this report.

AMENDMENTS TO SYSTEM DIAGRAM:

STATION: Chiang Mai, Thailand

1. The following parts are not at this station:

   L. D. G. O. Part Numbers: 1115, 3200-19, 3270, 3271, 3273-6, 3299, 3410, 3411, 3413, 3500, 3501, 3700, 4105, 4106, 4350.

2. Voltage regulator (#3270) not in operation: AC power from power distribution panel (#3424) to specific components.

3. Dehumidifiers (#3600, #4400) not in operation.

4. Small shelf mounted relay rack substituted for parts #3200 #3217.

5. Radio (#3218) not installed at station.

6. Antenna (#3219) not installed at station.

7. Time markers for standard and High-Gain photographic recorders (#4100) taken directly from existing WWSSN time console and not via time relay closures from digital clock (#3100).

8. Bulkhead door #3 (#5100) installed.

9. Filter galvanometers (#4350) were not installed.

10. 120 feet of 4 inch PVC pipe was used as signal cable conduit between the new vault and the WWSSN recording room.

VERTICAL

Seismometer:

Serial Number:	128
Free Period:	30 seconds

Magnets:	Lower -	before attachment:	2,500 gauss
		after attachment:	2,400 gauss
	Upper -	before attachment:	2,490 gauss

Coil Resistances:	Standard signal:	560 ohm
	Hi-Gain signal:	560 ohm
	Primary Calibration:	2,3 ohm
	Secondary Calibration:	2.6 ohm

CDRX (Critical for one signal coil): 5,400 ohm

Electromechanical Constant, G:

Standard Signal Coil:	R^{1}	=	94K	ohm
	V	=	1.4	volts
	G	=	131.5	newtons amp^{-1}
Hi-Gain Signal Coil:	R^{-1}	=	89K	ohm
	V	=	1.4	volts
	G	=	125	newtons amp^{-1}

Primary Calibration Coil:	R^1	=	28.8	ohm
	V	=	1.4	volts
	G	=	.04	newtons amps^{-1}
Secondary Calibration Coil:	R^1	=	26.7	ohm
	V	=	1.4	volts
	G	=	.037	newtons amps^{-1}

Cable Resistances:

Cable # 9	:	2.6 ohm
Cable # 10	:	1.0 ohm
Cable # 11	:	2.6 ohm
Cable # 12	:	2.6 ohm

Lo-Gain Galvanometer:

Serial Number:	124
Free Period:	102 seconds
CDRX Set:	4,000 ohm
Damping:	.7 critical
Current Sensitivity:	1.26×10^{-7} amp mm^{-1} at 1 meter

P. T. A. Galvanometer:

Serial Number:	102
Free Period:	102 seconds

CDRX Set: 4,000 ohm

Damping: .7

Current Sensitivity: 1.6×10^{-7} amp mm^{-1} at 1 meter

Hi-Gain Recording Galvanometer:

Serial Number: 4021

Free Period: .33 seconds

CDRX Set: 120 ohm

Damping: 1.0 critical

Current Sensitivity: 1.9×10^{-8} amp mm^{-1} at 1 meter

Gain Resistor: 1 meg ohm

Component Magnification:

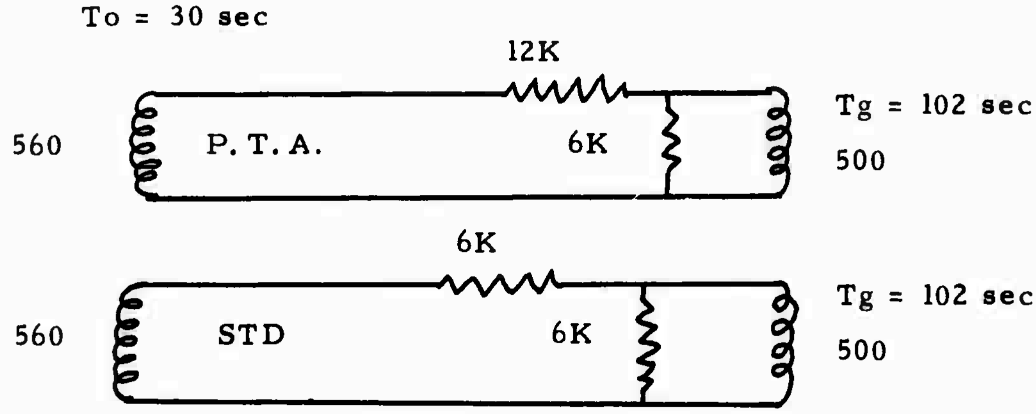
Lo-Gain: 6,000 at 30 seconds

Hi-Gain: 43K at 40 seconds

Remarks:

The final settings of the L-Pad attenuators are as follows:

To = 30 sec



NORTH - SOUTH

Seismometer:

Serial Number:	250	
Free Period:	30 seconds	
Magnets:	Level side:	2470 gauss
	Non-level side:	2530 gauss
Coil Resistance:	Standard signal:	560 ohm
	Hi-Gain signal:	560 ohm
	Primary Calibration:	2 ohm
	Secondary Calibration:	2 ohm

CDRX (Critical for one signal coil): 5800 ohm

Electromechanical constant, G:

Standard signal coil 5:	R^1	=	205K	ohm
	V	=	1.4	volts
	G	=	142	newtons amp^{-1}
Hi-Gain signal coil 6:	R^1	=	202K	ohm
	V	=	1.4	volts
	G	=	144	newtons amp^{-1}
Primary calibration coil 7:	R^1	=	63	ohm
	V	=	1.4	volts
	G	=	.042	newtons amp^{-1}

Secondary calibration coil 8:	R^1	=	61.2	ohm
	V	=	1.4	volts
	G	=	.043	newtons amp^{-1}

Cable resistances:

Cable # 5	:	2.6	ohm
Cable # 6	:	1.0	ohm
Cable # 7	:	2.6	ohm
Cable # 8	:	2.6	ohm

L0-Gain galvanometer:

Serial Number:	160
Free Period:	102 seconds
CDRX Set:	4,000 ohm
Damping:	.7 critical
Current Sensitivity:	1.28×10^{-7} amp mm^{-1} at 1 meter

P.T.A. galvanometer:

Serial Number:	128
Free Period:	102 seconds
CDRX Set:	4,000 ohm
Damping:	.7 critical
Current Sensitivity:	1.46×10^{-7} amp mm^{-1} at 1 meter

Hi-Gain recording galvanometer:

Serial Number: 3072

Free Period: .33 seconds

CDRX Set: 1.20 ohm

Damping: 1.0 critical

Current Sensitivity: 1.6×10^{-8} amp mm^{-1} at 1 meter

Gain resistor: 1 meg ohm

Component magnification:

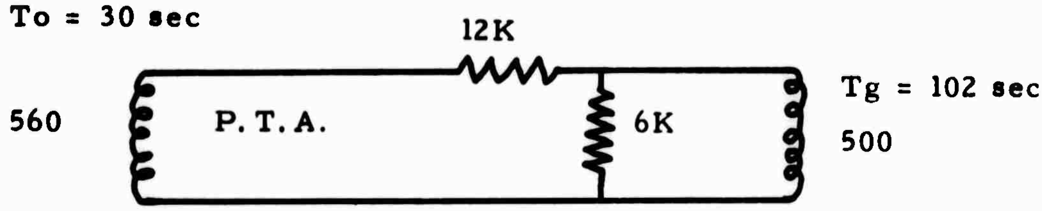
Lo-gain: 6,000 at 30 seconds

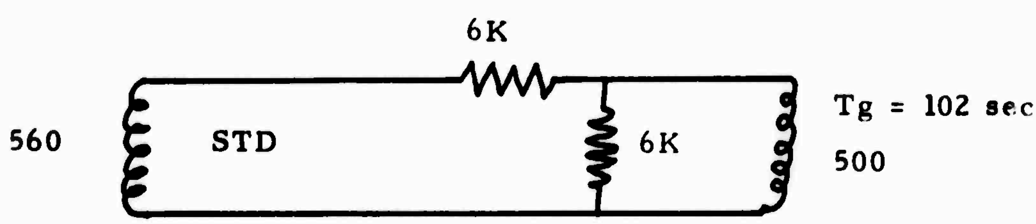
Hi-gain: 59K at 50 seconds

Remarks:

The final settings of the L-pad attenuators are as follows:

To = 30 sec





EAST - WEST

Seismometer:

Serial Number:	251		
Free Period:	30 seconds		
Magnets:	Level side:	2475	gauss
	Non-level side:	2460	gauss
Coil Resistances:	Standard signal:	605	ohm
	Hi-Gain signal:	640	ohm
	Primary Calibration:	2.2	ohm
	Secondary Calibration:	2.2	ohm

CDRX (Critical for one signal coil): 5900 ohm

Electromechanical constant, G:

Standard signal coil 1:	R^1	=	200K	ohm
	V	=	1.4	volts
	G	=	140	newtons amp^{-1}
Hi-gain signal coil 2:	R^1	=	200K	ohm
	V	=	1.4	volts
	G	=	140	newtons amp^{-1}
Primary calibration coil 3:	R^1	=	61.2	ohm
	V	=	1.4	volts
	G	=	.043	newtons amp^{-1}

Secondary calibration coil 4:	R^1	=	61.2	ohm
	V	=	1.4	volts
	G	=	.043	newtons amp^{-1}

Cable resistances:

Cable # 1	:	2.6	ohm
Cable # 2	:	1.0	ohm
Cable # 3	:	2.6	ohm
Cable # 4	:	2.6	ohm

Lo-gain galvanometer:

Serial Number:	115
Free Period:	99 seconds
CDRX Set:	4000 ohm
Damping:	.7 critical
Current sensitivity:	1.36×10^{-7} amp mm^{-1} at 1 meter

P.T.A. galvanometer:

Serial Number:	120
Free Period:	104 seconds
CDRX Set:	4000 ohm
Damping:	.7 critical
Current Sensitivity:	1.23×10^{-7} amp mm^{-1} at 1 meter

Hi-Gain recording galvanometer:

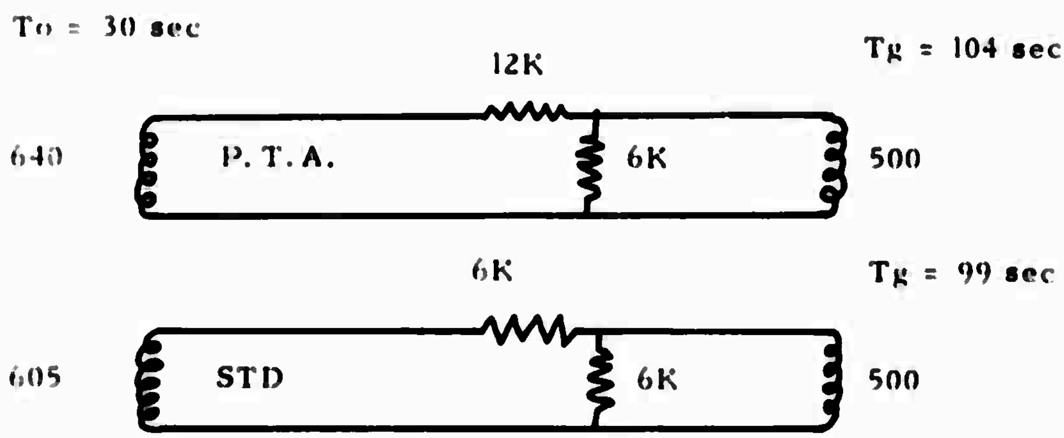
Serial Number:	3931
Free Period:	.33 seconds
CDRX Set:	120 ohm
Damping:	1.0 critical
Current sensitivity:	1.9×10^{-8} amp mm^{-1} at 1 meter
Gain resistor:	1. meg ohm

Component magnification:

Lo-gain:	6,000 at 30 seconds
Hi-gain:	43 K at 40 seconds

Remarks:

The final settings of the L-pad attenuators are as follows:



PHOTOGRAPHIC RECORDERS:

Low-Gain:	Rotation Speed:	15 mm/minute
	Translation Speed:	10 mm/revolution
High-Gain:	Rotation Speed:	15 mm/minute
	Translation Speed:	10 mm/revolution

DISPLACEMENT TRANSDUCERS:

Vertical:	**Serial Number:**	**3960**
	Sensitivity:	**5.0 mV/micron**
	Range of Linearity (±0.1%):	**3.4 mm peak to peak about center of oscillation**
North-South	**Serial Number:**	**3899**
	Sensitivity:	**5.4 mV/micron**
	Range of Linearity (±0.1%):	**4.0 mm peak to peak about center of oscillation**
East-West	**Serial Number:**	**3959**
	Sensitivity:	**4.9 mV/micron**
	Range of Linearity (±0.1%):	**3.3 mm peak to peak about center of oscillation**

DIGITAL DATA ACQUISITION SYSTEM:

Station I. D. : 02

Input Channels	Written on tape	Sampling Rate Samples per Second	Instrument
1	Yes	One sample per second	Z velocity
2	Yes	One sample per second	N-S velocity
3	Yes	One sample per second	E-W velocity
4	No		
5	No		
6	No		
7	No		
8	No		
9	No		
10	No		Test channel
11	Yes	One sample per 5 seconds	Z displacement
12	Yes	One sample per 5 seconds	N-S displacement
13	Yes	One sample per 5 seconds	E-W displacement
14	No		
15	No		
16	No		

ACKNOWLEDGMENTS

The author wishes to thank the Meteorological Department of the Office of the Prime Minister of Thailand for making the site at Chiang Mai available for the construction of a new vault and the installation of this seismograph system. Particular thanks are due to Dr. Charoen Charoen-Rajapark, Director General of the Meteorological Department, who did much to facilitate this installation, to Dr. Wiroj Sangvaree, who designed the vault, to Lt. La-Iad Sungchaya, who supervised the construction of the vault and assisted in the installation of the equipment, and to Lt. Sukit Yeansaung and Aurachoon Jayavanana, who assisted with logistic support and technical aid during the installation. The author also wishes to thank Messrs. George P. Hade, Jr., John M. W. Rynn, Drs. Peter Ward, John Savino, and Bryan Isacks for their advise and criticism during the preparation of this report.

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World-Wide Standard Seismograph Network Handbook (1966): University of Michigan.

APPENDIX I

PHOTOGRAPHS OF INSTALLATION

Plate 1: Initial preparation of the bedrock surfaces beneath the new vault.

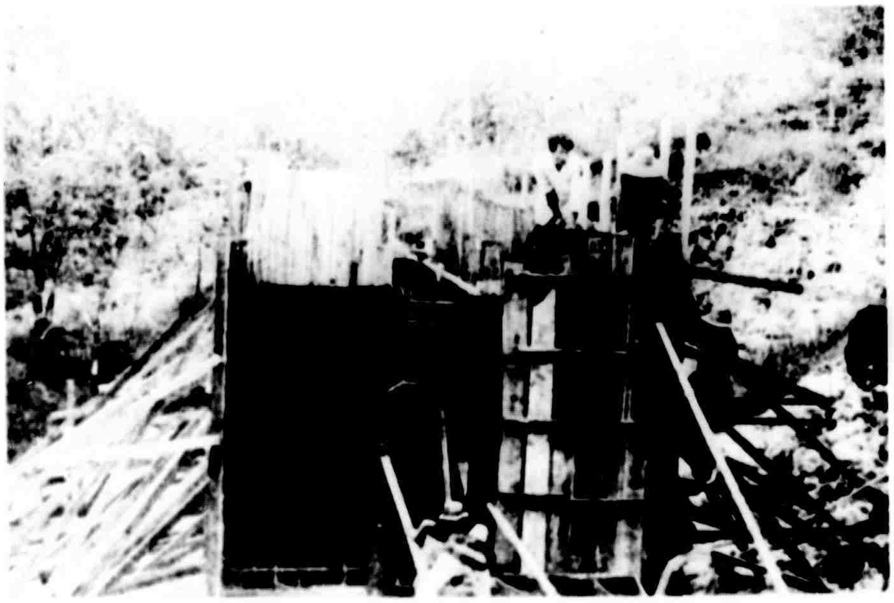


Plate 2: Forming the walls of the new vault in preparation for pouring the concrete.

Plate 3: Pouring and troweling the roof of the vault.

Plate 4: Backfilling around the vault.

Plate 5: Meteorological Dept. personnel observing completion of the new vault. (Dr. Charoen Charoen-Rajapark (on left), Lt. La-Iad Sungehaya (second from left), and Dr. Wiroj Sangvaree (third from right).

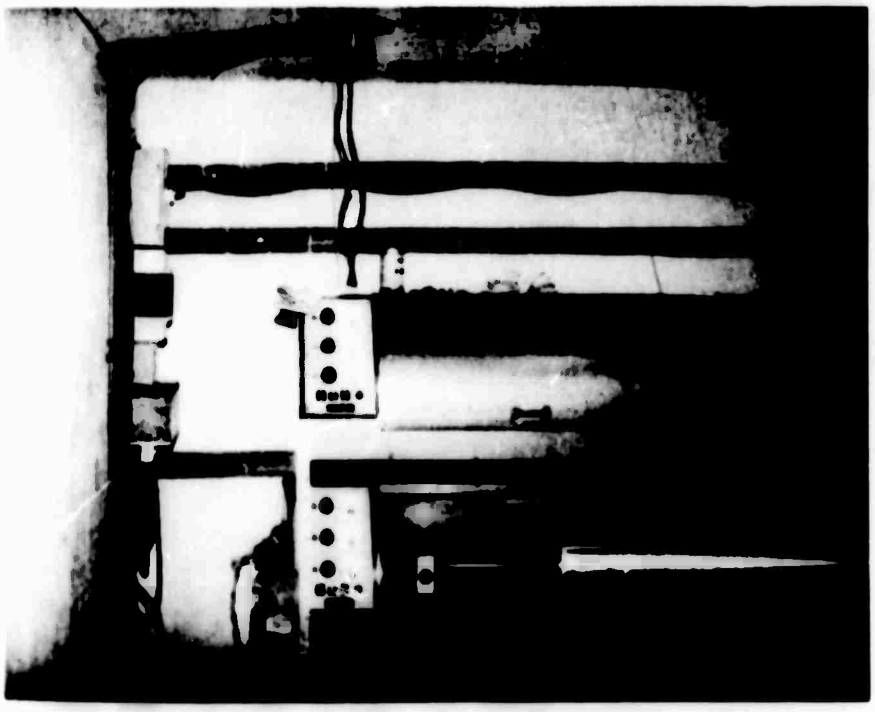


Plate 6: Stacked photographic recorders and the system power distribution panel on the left. Recording drum in foreground is part of the WWSSN system.

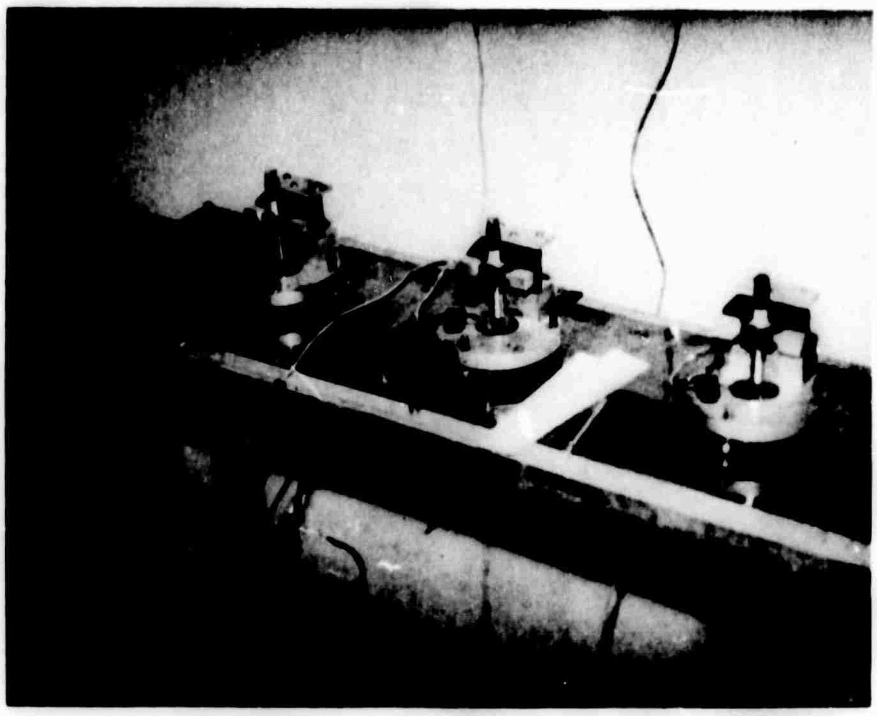


Plate 7: Top: wood-topped steel bench for short-period, high-gain, recording galvanometers.
Bottom: Aluminum base plate for the long-period low-gain, recording galvanometer enclosures.

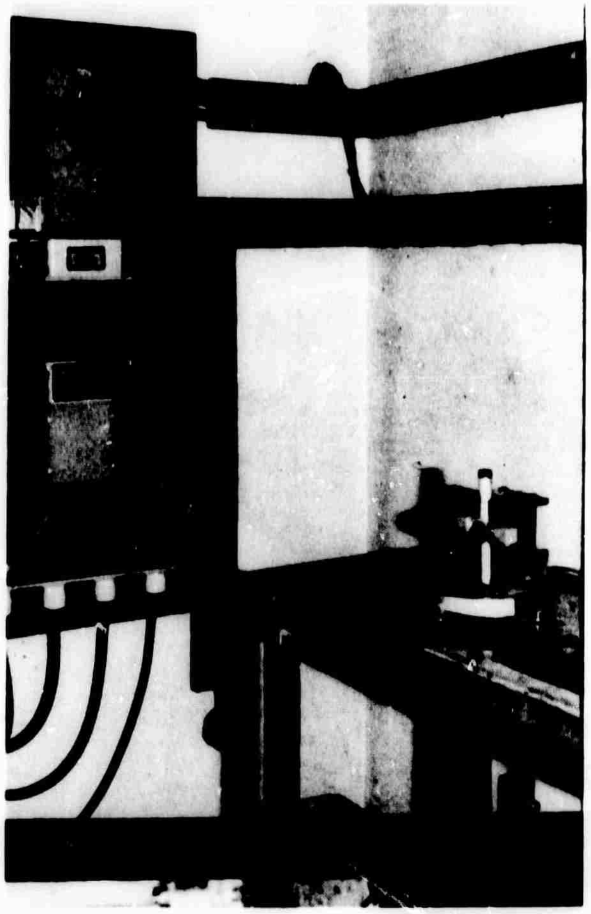


Plate 8: Cables routed along teak boards firmly attached to the walls. Power distribution panel is on the left.

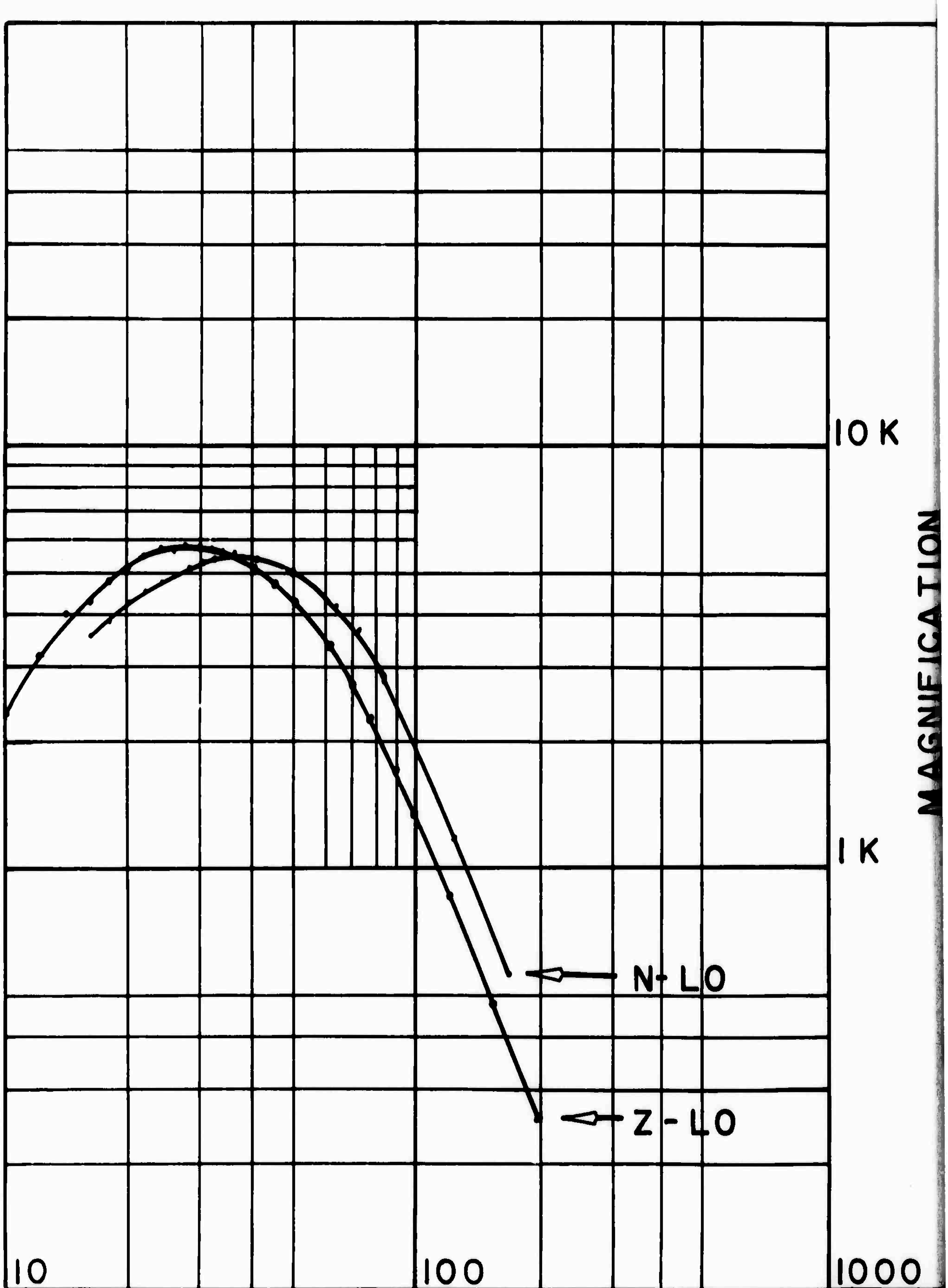
Plate 9: External routing of cables through 4" PVC pipe. AC power pole is in center; WWSSN vault and recording building is on the right.

Plate 10: Horizontal seismometer being filled with Argon.

APPENDIX II

FREQUENCY RESPONSE CURVES

A



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FREQUENCY RESPONSE OF
HIGH-GAIN, LONG-PERIOD
SEISMOGRAPH STATION AT
CHIANG MAI, THAILAND

STANDARD GAIN COMPONENTS

Z MAX. GAIN 5.8K AT 30 SEC.

NS MAX. GAIN 5.5K AT 32 SEC.

EW UNAVAILABLE AT
PRESENT DUE TO
TECHNICAL PROBLEMS

10K

MAGNIFICATION

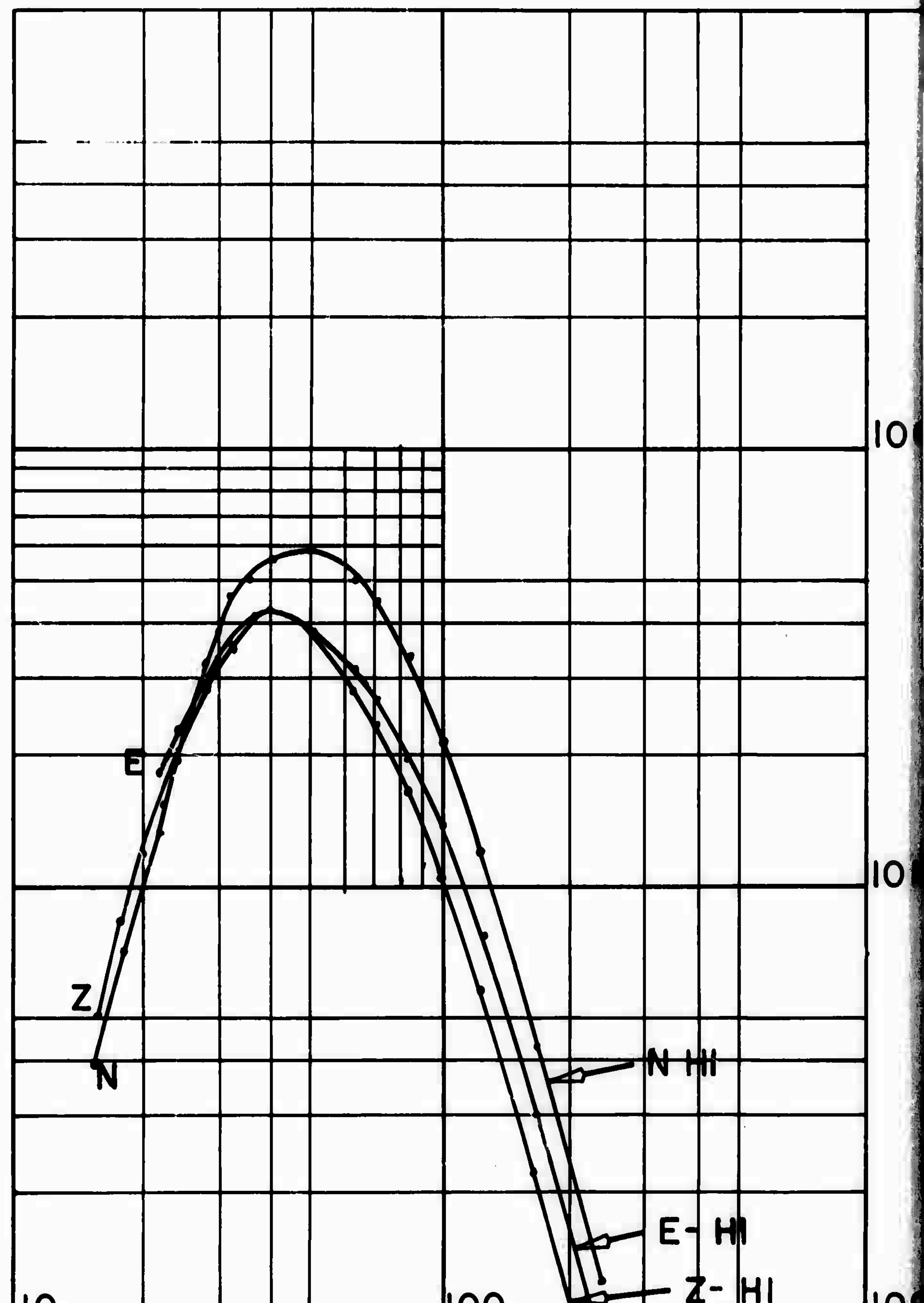
1K

10

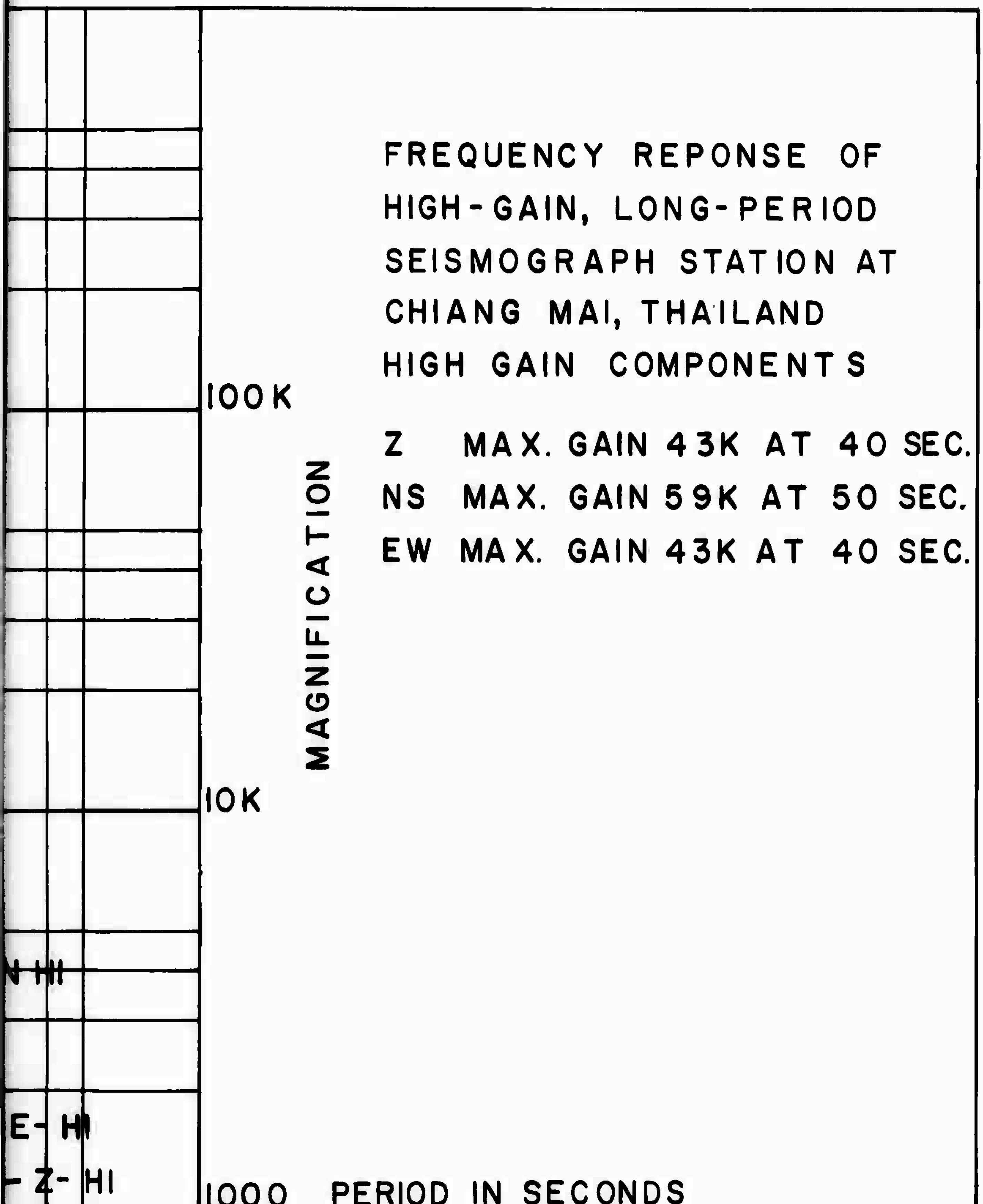
10

1000 PERIOD IN SECONDS

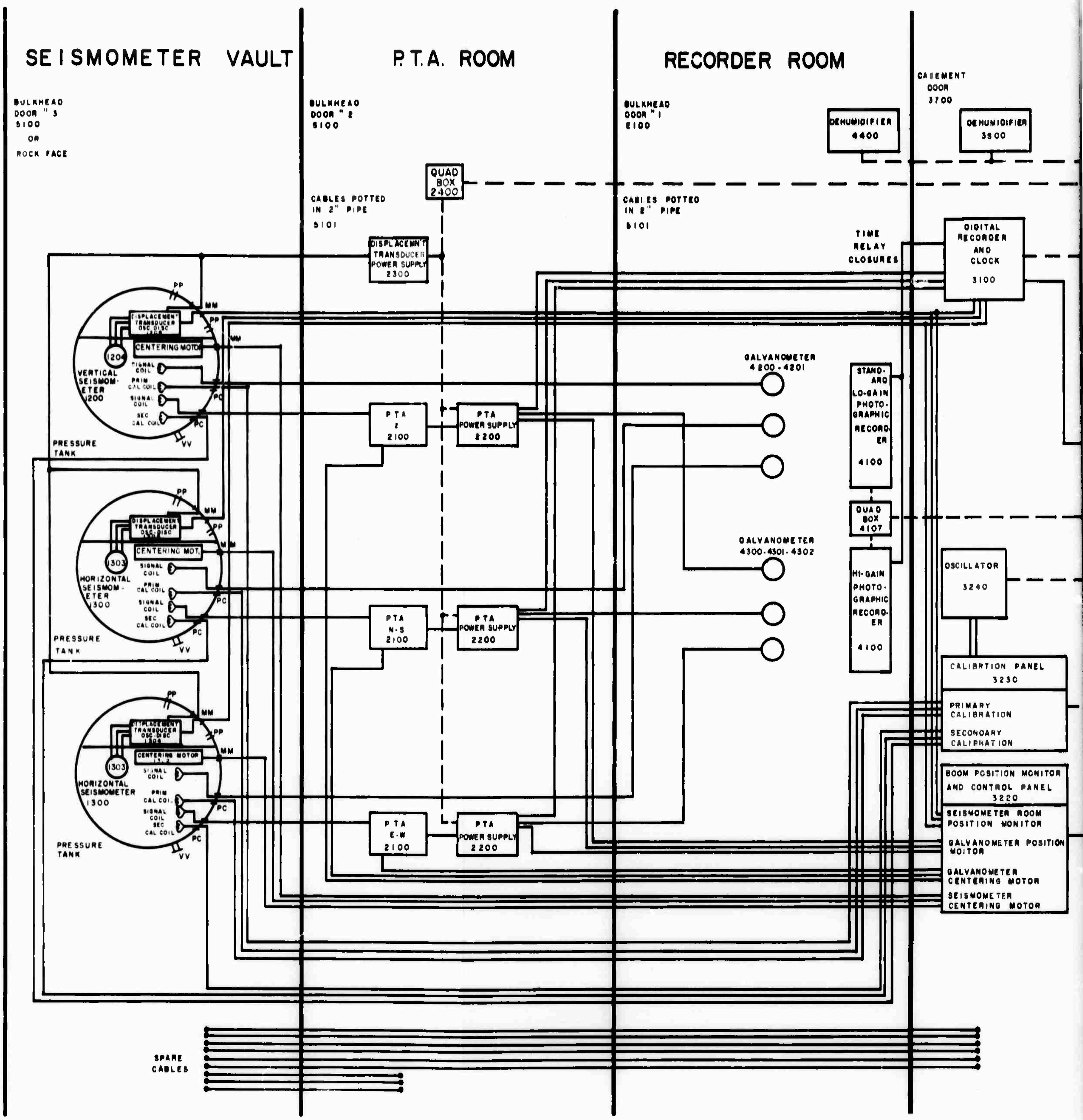
A



1 B

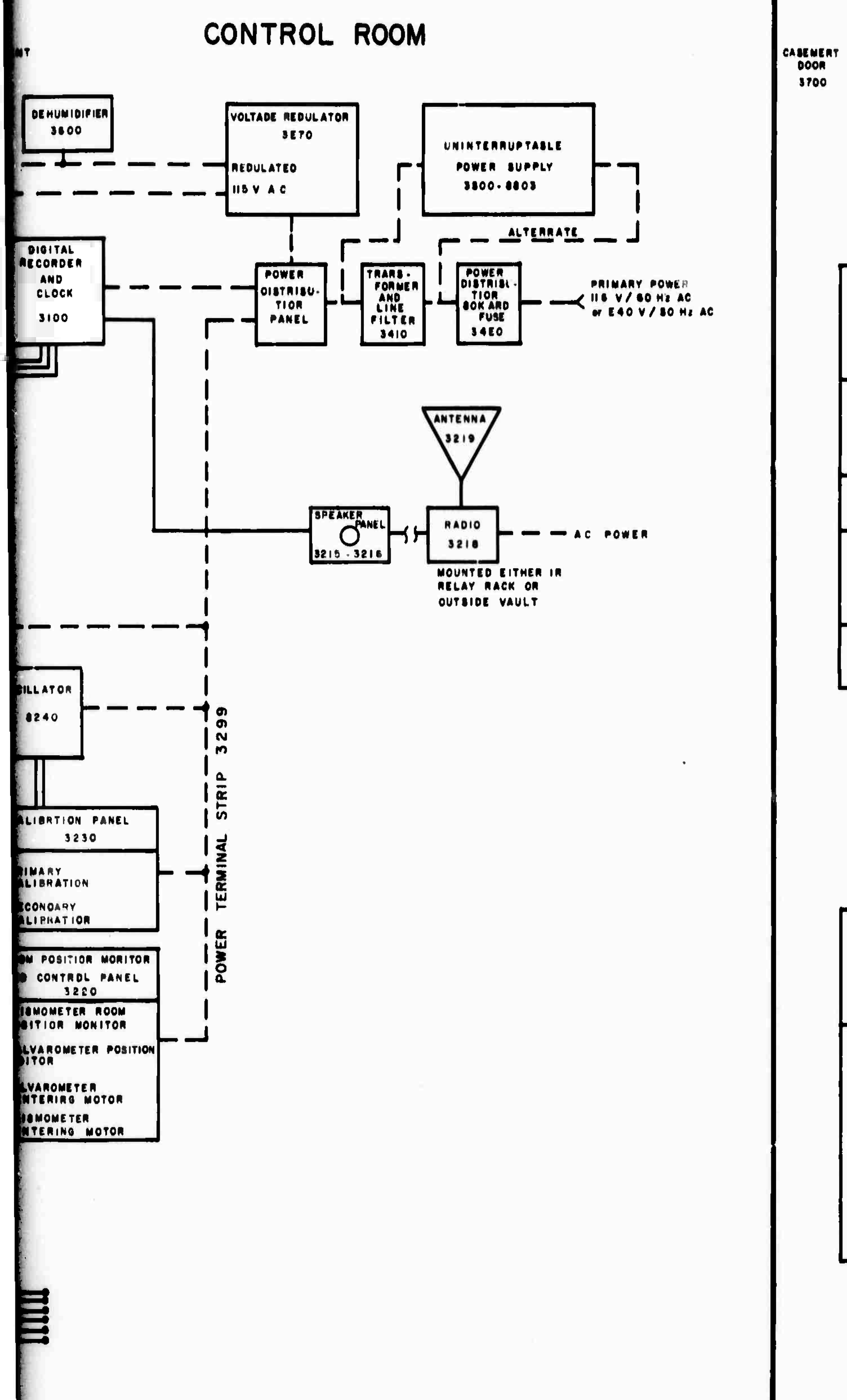

FREQUENCY REPONSE OF
HIGH-GAIN, LONG-PERIOD
SEISMOGRAPH STATION AT
CHIANG MAI, THAILAND
HIGH GAIN COMPONENTS
Z MAX. GAIN 43K AT 40 SEC.
NS MAX. GAIN 59K AT 50 SEC.
EW MAX. GAIN 43K AT 40 SEC.
100K
10K
1000
MAGNIFICATION
PERIOD IN SECONDS
N HI
E- HI
Z- HI

A



SEISMOMETER VAULT
P.T.A. ROOM
RECORDER ROOM
BULKHEAD DOOR " 3 5100 OR ROCK FACE
BULKHEAD DOOR " 2 5100
BULKHEAD DOOR " 1 E100
CASEMENT DOOR 3700
DEHUMIDIFIER 4400
DEHUMIDIFIER 3500
QUAD BOX 2400
CABLES POTTED IN 2" PIPE 5101
CABLES POTTED IN 2" PIPE 5101
DISPLACEMENT TRANSDUCER POWER SUPPLY 2300
TIME RELAY CLOSURES
DIGITAL RECORDER AND CLOCK 3100
VERTICAL SEISMOMETER 1200
1204
CENTERING MOTOR
SIGNAL COIL
PRIM CAL COIL
SIGNAL COIL
SEC CAL COIL
PRESSURE TANK
GALVANOMETER 4200-4201
PTA 2100
PTA POWER SUPPLY 2200
STANDARD LO-GAIN PHOTOGRAPHIC RECORDER 4100
QUAD BOX 4107
HORIZONTAL SEISMOMETER 1300
1303
CENTERING MOT.
GALVANOMETER 4300-4301-4302
HI-GAIN PHOTOGRAPHIC RECORDER 4100
OSCILLATOR 3240
PTA N-S 2100
PTA POWER SUPPLY 2200
CALIBRTION PANEL 3230
PRIMARY CALIBRATION
SECONDARY CALIBRATION
HORIZONTAL SEISMOMETER 1300
BOOM POSITION MONITOR AND CONTROL PANEL 3220
PTA E-W 2100
PTA POWER SUPPLY 2200
SEISMOMETER ROOM POSITION MONITOR
GALVANOMETER POSITION MOITOR
GALVANOMETER CENTERING MOTOR
SEISMOMETER CENTERING MOTOR
SPARE CABLES
PP
MM
PC
VV

I B



SYMBOLS USED ON PRESSURE TANK		
VV	PRESSURE TANK VENT VALVE	1102
PC	POTTED CABLES	8208
MM	MARSH - MARINE CONNECTORS	1101 1103
PP	PIPE PLUG	1104

LAMONT - DOHERTY GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY

HIGH - GAIN BROAD - BAND LONG - PERIOD SEISMIC SYSTEM